


Requirements and traffic dimensioning for system concepts and architecture

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WP2 Contributors

WP2 Work in progress

Completed:

•D2.1- Requirements for European next-generation optical access networks (deadline : 30.09.2010)

Upcoming:

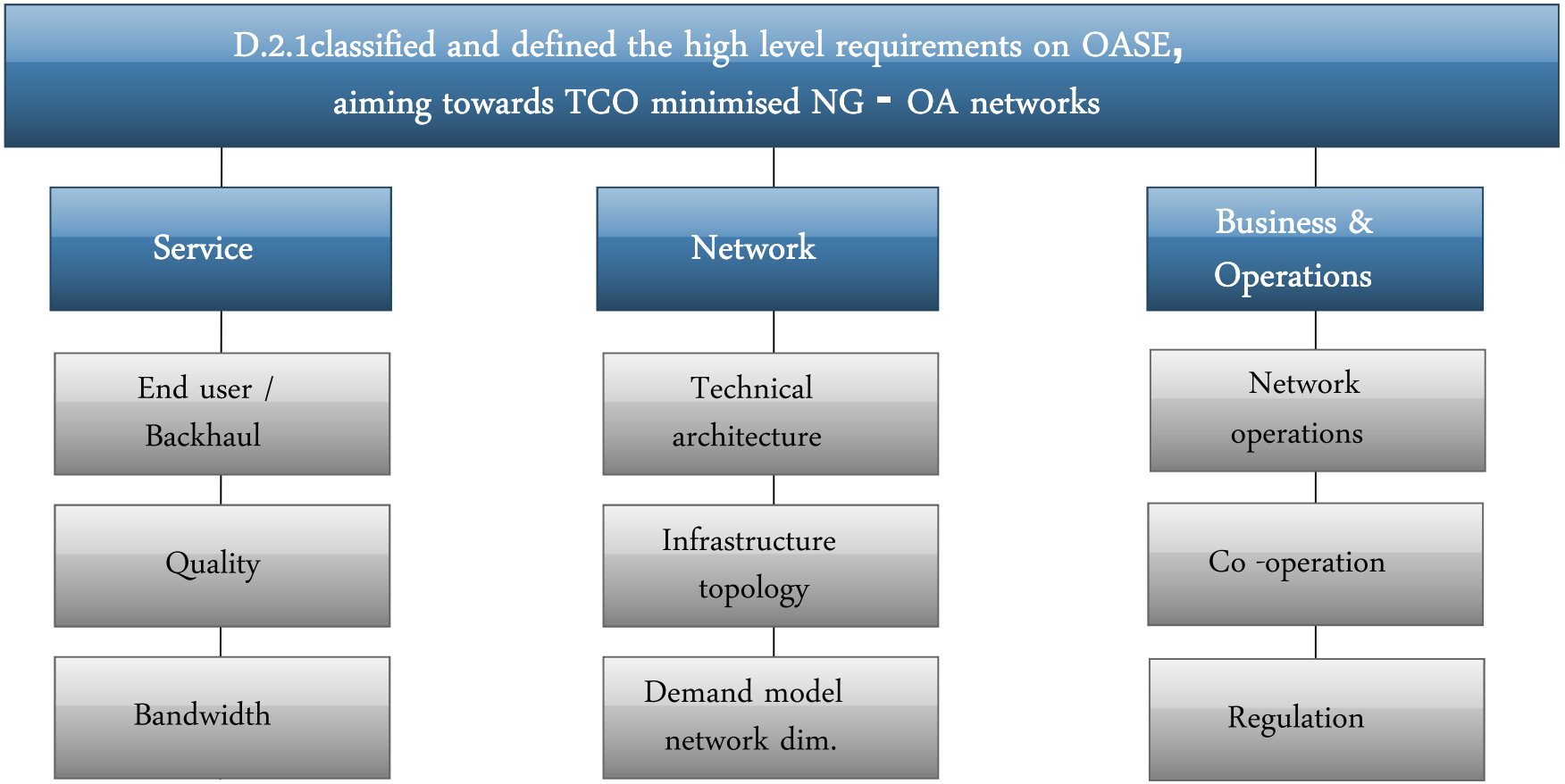
•D2.2 – Refinement of the results based on other workpackages:
technical feasibility, economical impact
(exact deadline to be defined)

WP2 Achievements

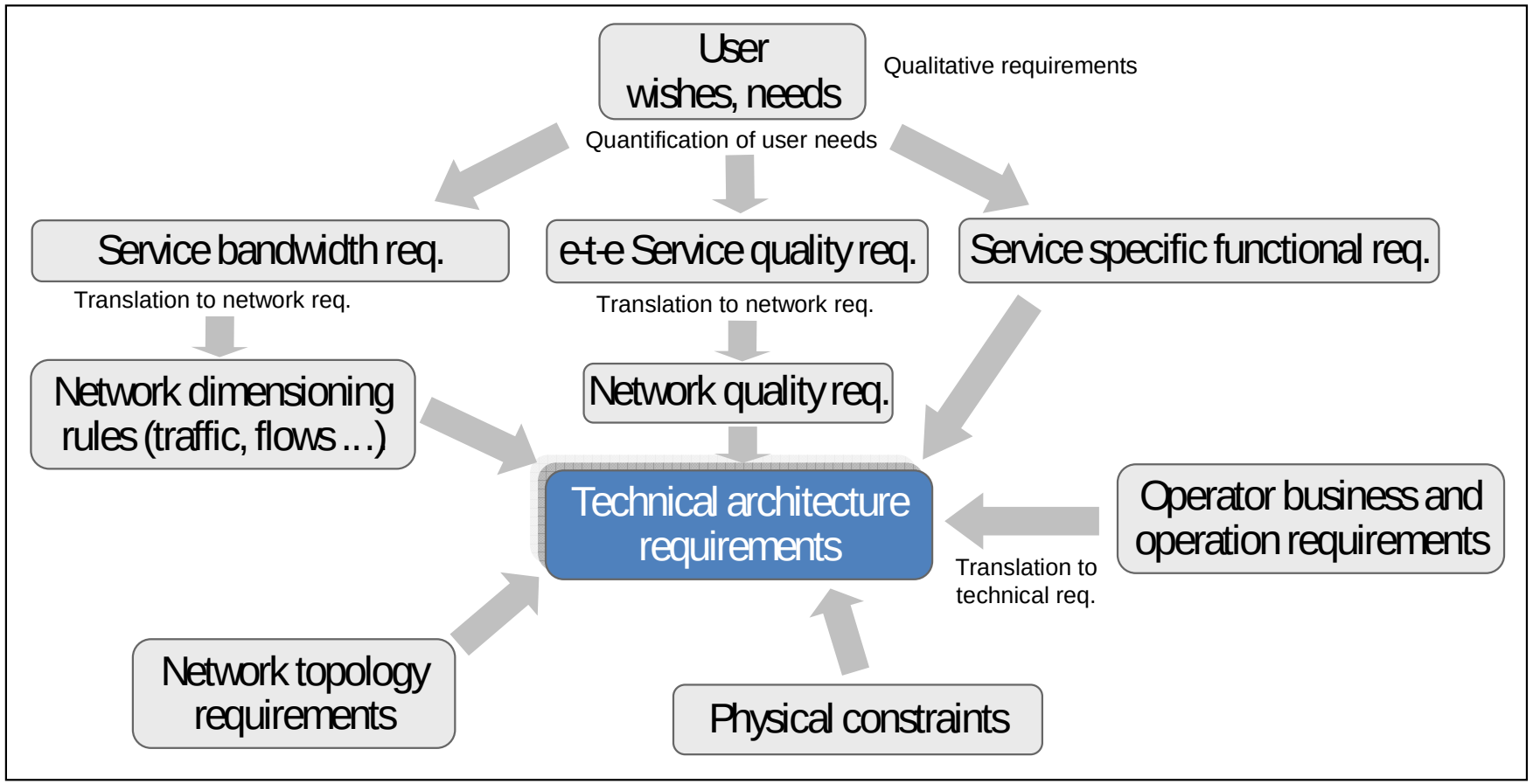
Key features of Deliverable 2.1:

- requirements are **consolidated** and based on collaborative work of vendors, operators and scientific institutes
- already existing **standards** and models were taken into consideration
- definitions for possible future **usage options** are included (backhauling fixed, mobile)
- where possible, concrete **values** and **numbers** were included as requirements in the definitions (e.g. quality, bandwidth, backhaul, dimensioning etc..)
- **real life** statistical and measurement data were used
- new models and **guiding priciples** were established as a basis of work for other workpackages of the OASE project

WP2 Achievements



Requirements workflow

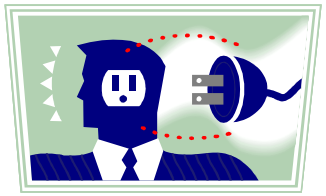


End user requirements

FTTH Residential:

- Full service access
- Data security and integrity
- High quality, accessibility and retainability
- Low up- and download time

- **Business:**
- Same or even better like residential
- High availability
- Special troubleshooting requirements
  (e.g. 4 hour service for fault recovery)



Plug and Play techniques

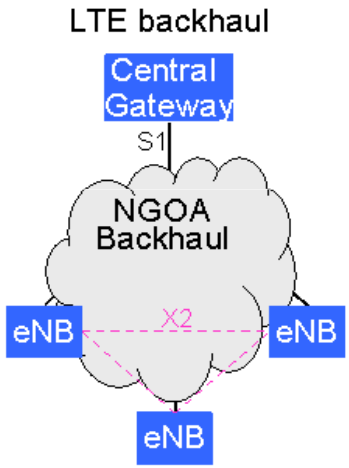
User requirements:	QoS service requirements:
• Accessibility	• Blocking probability
	• Network availability
• Retainability	• Set-up time
	• Network robustness
• Correctness	• Throughput (Bandwidth)
	• Delay
• Resolution	• Jitter
	• BER
• Duration	• Packet loss rate

Mininized administration of CPE equipment by end-user

Mobile Backhaul requirements

LTE Version

NGOA – Mobile backhaul



Shared LTE RAN: 2-3 operators –

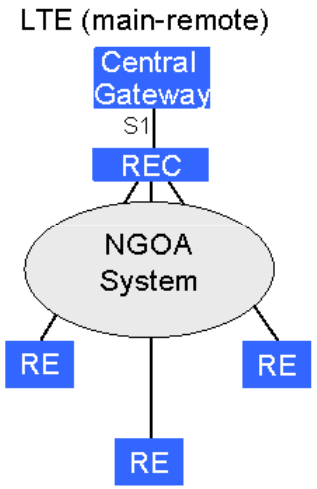
Requirement estimates for a 3-sector RBS for LTE, LTE-A, LTE-A with CoMP

	S1					X2	
	Peak rate	Average data rate per site	Latency	Freq. accuracy	Timing accuracy	Bit rate	Latency
LTE	519 Mbit/s (DS) 174 Mbit/s (US)	100 Mbit/s (DS) 40 Mbit/s (US)	5 ms	+/-50 ppb	1 to 50 µsec	Several kbit/s (e.g. handover info)	20 ms
LTE-A (R10)	3Gbit/s (DS) 1.5 Gbit/s (US)	1 Gbit/s (DS) 0.5 Gbit/s (US)	5 ms	+/-50 ppb	1 to 50 µsec	Several kbit/s (e.g. handover info)	20 ms
LTE-A (CoMP)	3Gbit/s (DS) 1.5 Gbit/s (US)	1 Gbit/s (DS) 0.5 Gbit/s (US)	5 ms	+/-5 ppb	~1 µsec may be required	From 10 Mbit/s to multiple Gbit/s (≥2 Gbit/s required in worst case)	Examples: 1–10 ms, 0.5–5 ms, 1 ms (below 1 ms required in worst case).

CoMP – Coordinated Multi Point

Mobile backhaul requirements (alternative)

NGOA – Mobile network with distributed RBS architecture



Advantage:

•Potential cost and energy savings

Disadvantage:

•Increased transmission requirements

Example requirements per RE (one sector) for the evolved ORI in a distributed RBS configuration (extrapolated from CPRI requirement).

	ORI		
	Peak rate	**Frequency accuracy**	**Link timing accuracy**
LTE	1.07 Gbit/s (DS) 504 Mbit/s (US)	+/- 2 ppb	8.138 ns
LTE-A	6.14 Gbit/s (DS) 3.07 Gbit/s (US)	+/- 2 ppb	8.138 ns

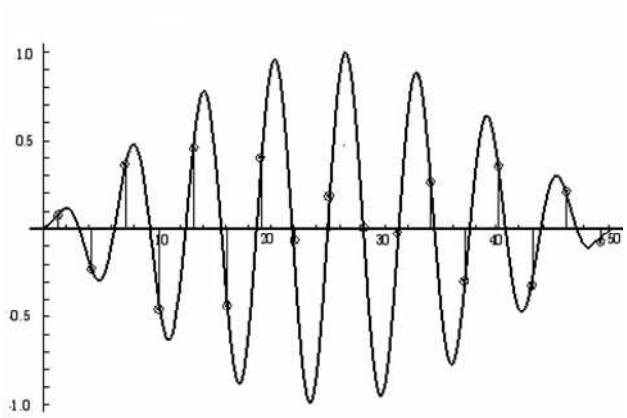
Fixed backhaul requirements

FTTx DSL solutions:

- FTTC/VDSL (street cabinets)
- FTTB/VDSL (within buildings)

CATV node units:

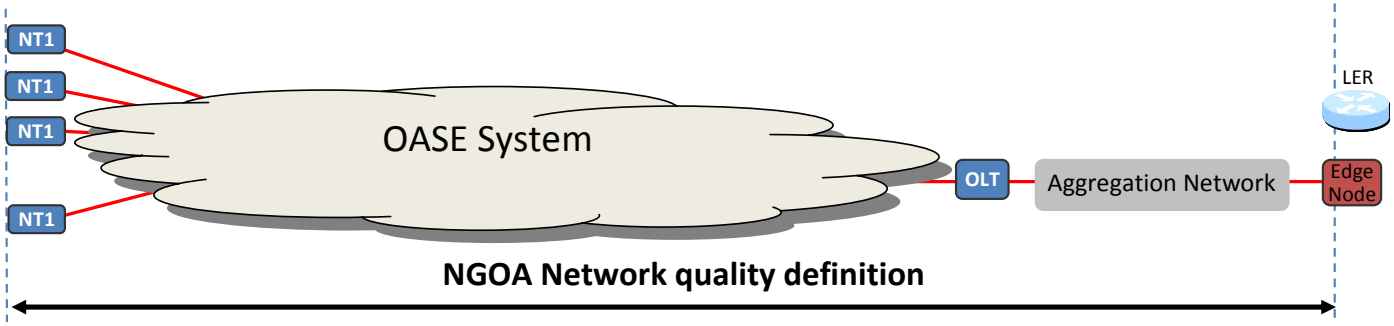
- Analogue TV/radio
- DVB-C
- EuroDOCSIS



Support of technologies with analogue modulation !

Quality requirements

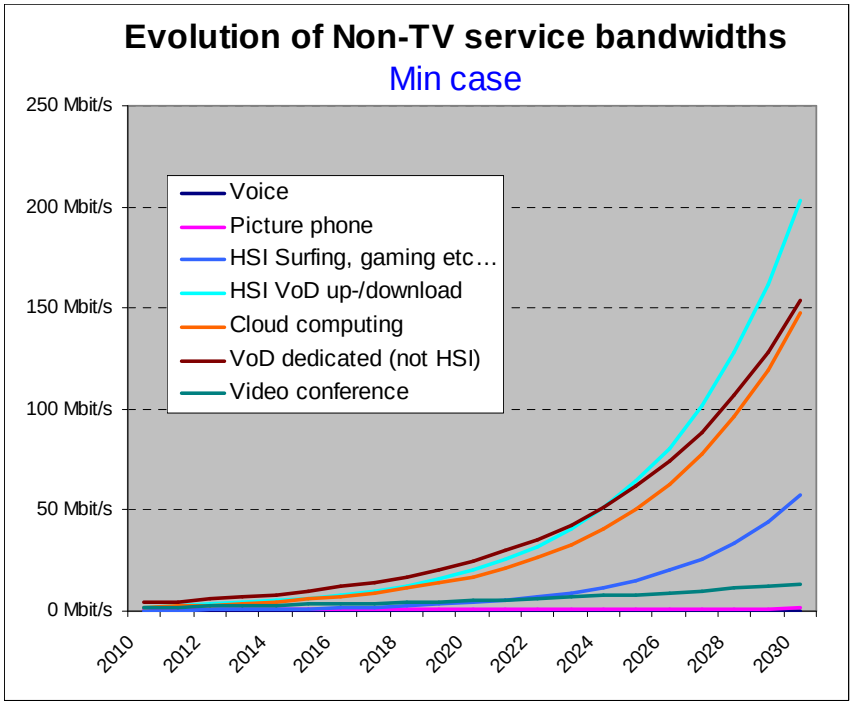
Multiple Service Acces Everywhere

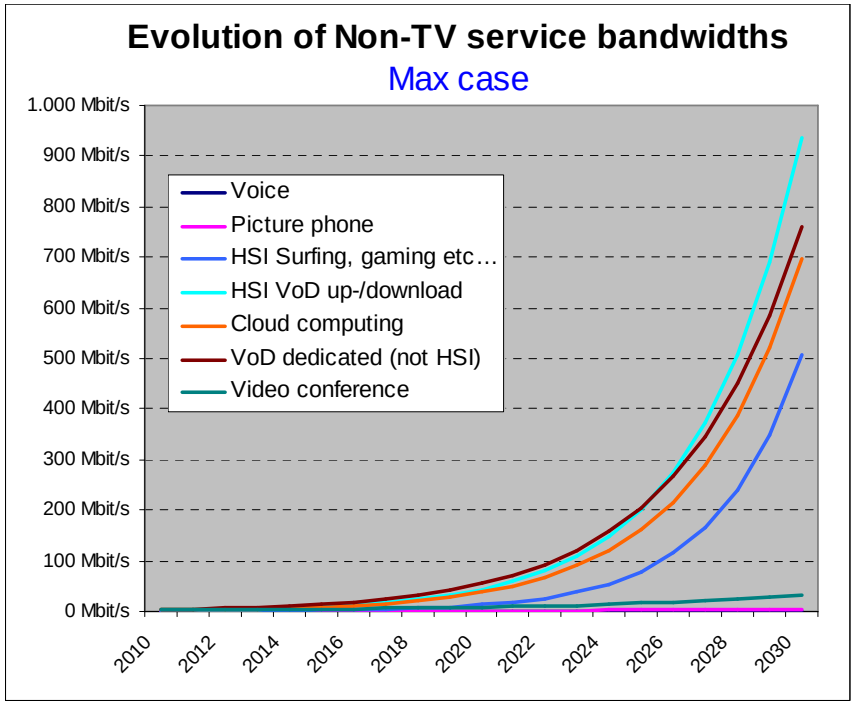


Services class	NGOA network quality parameter*				
	Availability	Delay	Jitter	BER	Packet loss rate
Real Time	>99,99%	< 5ms	< 1ms	< 1,00E-06	< 1,00E-04
Streaming	>99,99%	< 40ms	< 10ms	< 1,00E-06	< 1,00E-04
Transactional	>99,99%	< 100ms	N.A	< 1,00E-08	< 1,00E-06
Best effort	>99,99%	< 200ms	N.A	N.A	N.A
Business	>99,99%	< 5ms	< 20ms	< 1,00E-08	< 1,00E-06
Mobile LTE- Backhaul	>99,99%	< 5ms	<< 1ms	< 1,00E-08	< 1,00E-06
Mobile LTE advanced- Backhaul	>99,99%	< 1ms	<< 1ms	< 1,00E-08	< 1,00E-06
Fixed backhaul- Backhaul	>99,99%	< 5 ms	<< 1ms	< 1,00E-08	< 1,00E-06

* Parameters denoted for access/aggregation network section

Bandwidth requirements





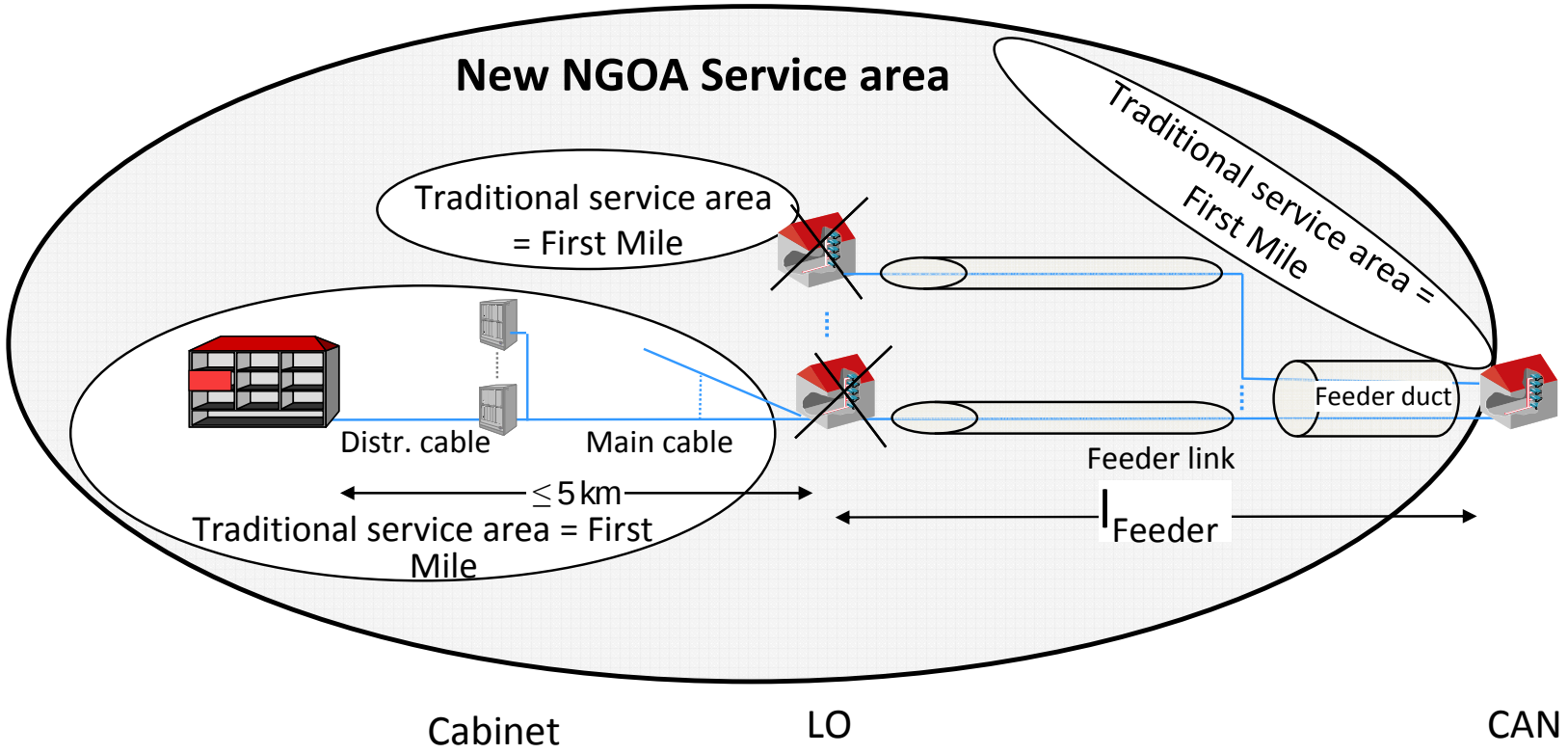
Estimated evolution of Non-TV service bandwidths (based on Cisco's studies and operator data)

- FTTH residential peak data rates > 1 Gbit/s
- Business, backhaul (fixed, mobile) peak rate: $\geq$10 Gbit/s

Technical architecture requirements

- Legacy ODN **compatibility**: Passive, not wavelength selective, single fibre
- **Multi-stage** splitter architectures: High system and infrastructure sharing: 256 - 1024 users on a single feeder fibre
- **Migration** without affecting the deployed system
- Support of **redundancy and protection** mechanism for service availability
- **Common access and aggregation** for residential, business, fixed and Mobile backhaul/RAN transport
- Efficient **distribution** of content (e.g. Multicast, optimised CDN structure ...)
- Support of **IPv6**
- **Resource** control and management
- **Security** better than XG-PON1

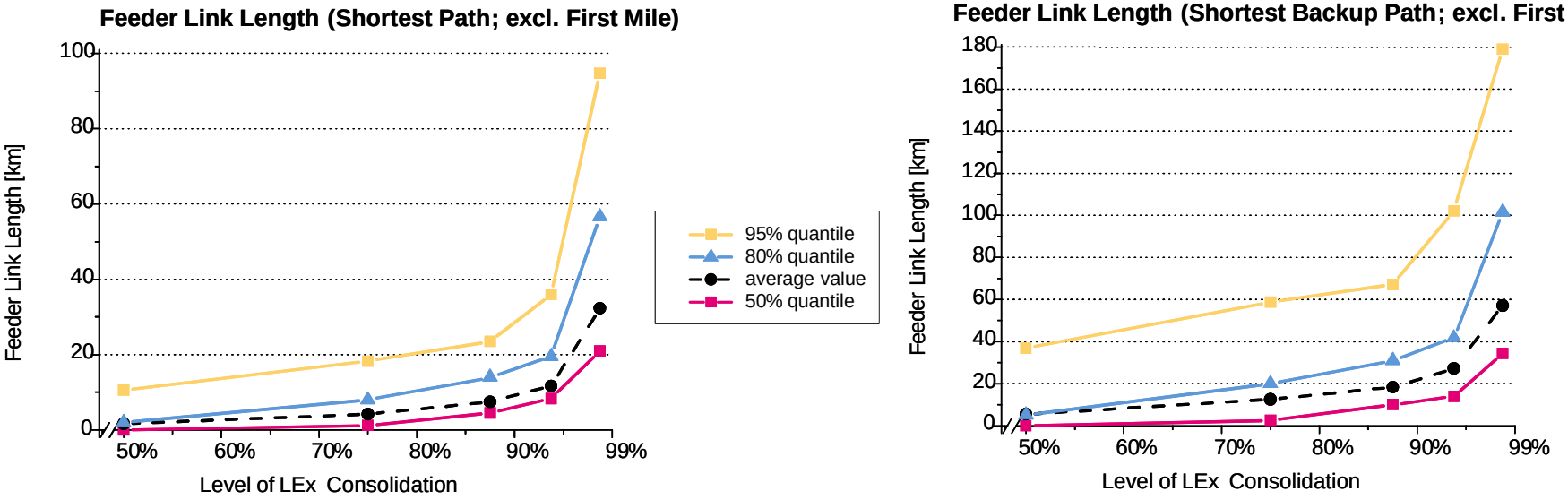
Infrastructure and topology requirements



Network location consolidation principle with consolidation of smaller offices

Reach requirements (Based on statistical Data from DT's Network)

Feeder Length (excl. local loop) and Backup Feeder length



+ 5km typically first mile length of the traditional „copper" service area

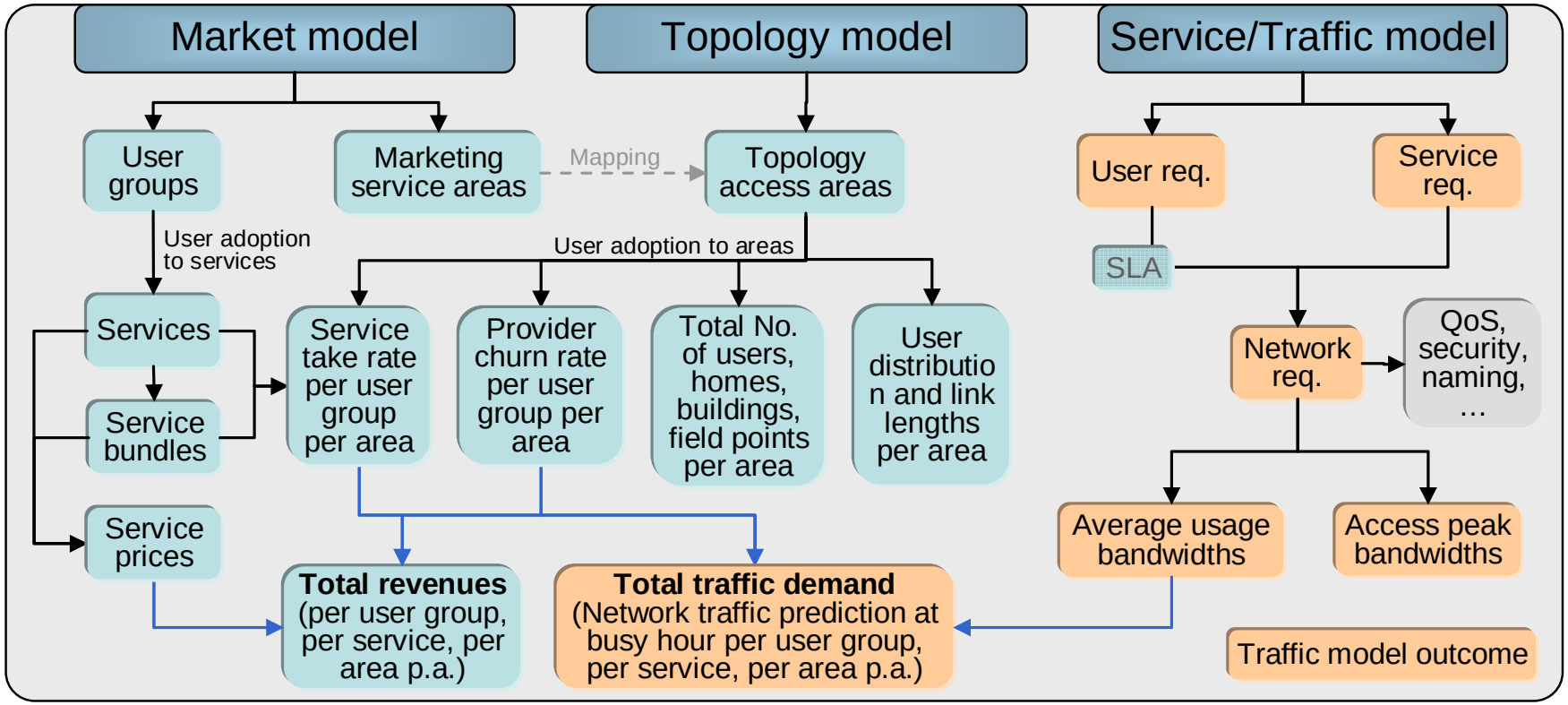
Case 1: 60% node consolidation, 95% quantile → working path 20 km, protection path 60 km

Case 2: 90% node consolidation, 95% quantile → working path 40 km, protection path 90 km

Conclusion:

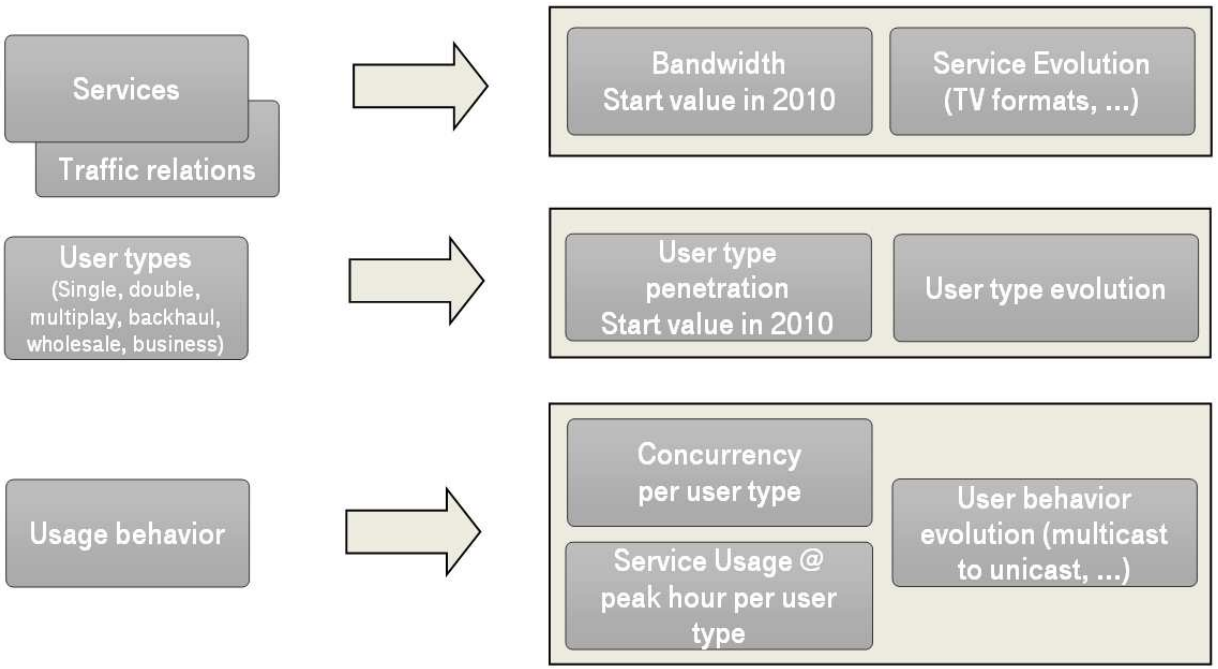
- Support of 20 to 40 km passive reach for the working path, depending on the degree of node consolidation
- Support of 60 to 90 km extended reach option for the protection path, depending on the degree of node consolidation
- Extended reach should be realized passively (preferred solution)

Traffic dimensioning



Overall demand model

Traffic dimensioning

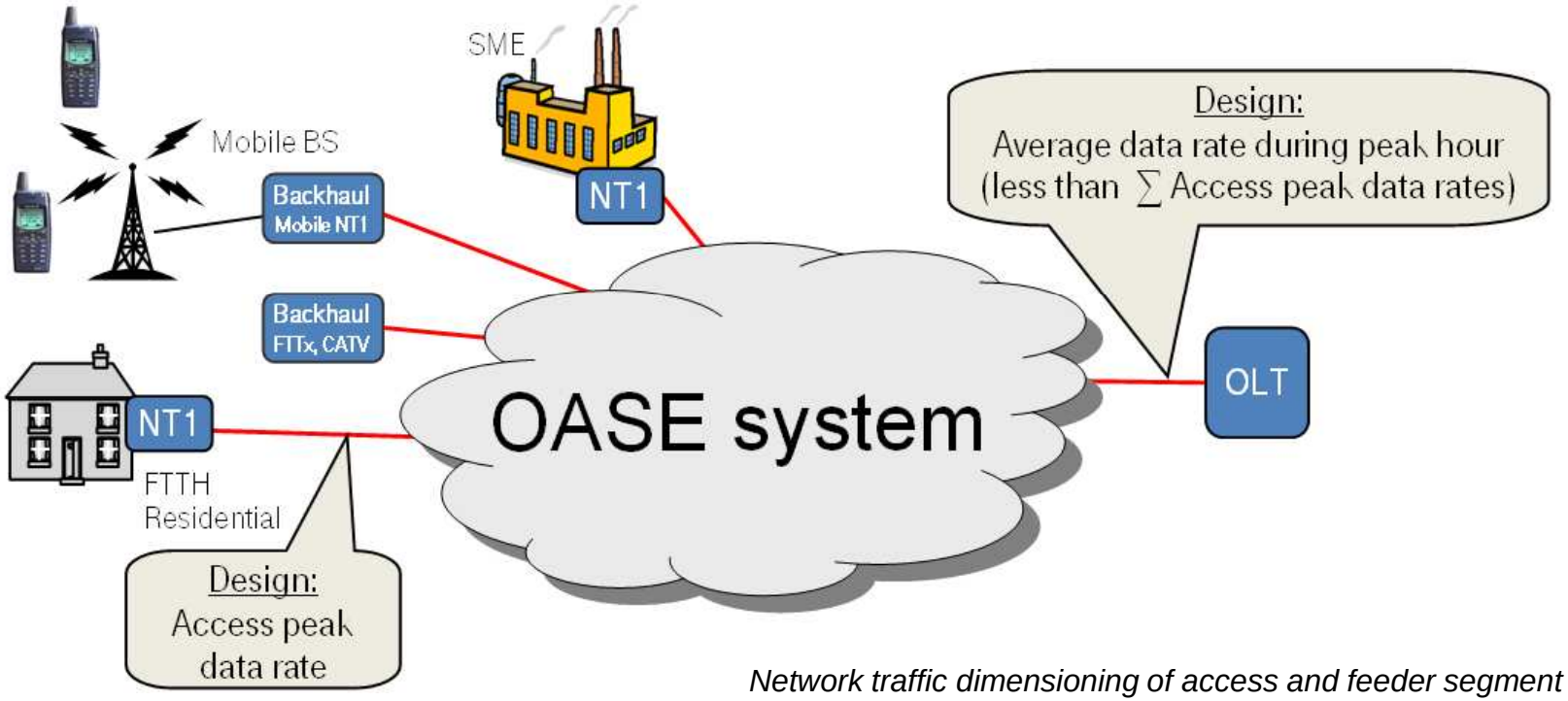


Main building blocks for Traffic Modelling

Output of the traffic modelling:

- Sustainable traffic per user (per user and total)
- Total sustainable traffic per user type (considering symmetry ratio per service according to the bandwidth requirements)

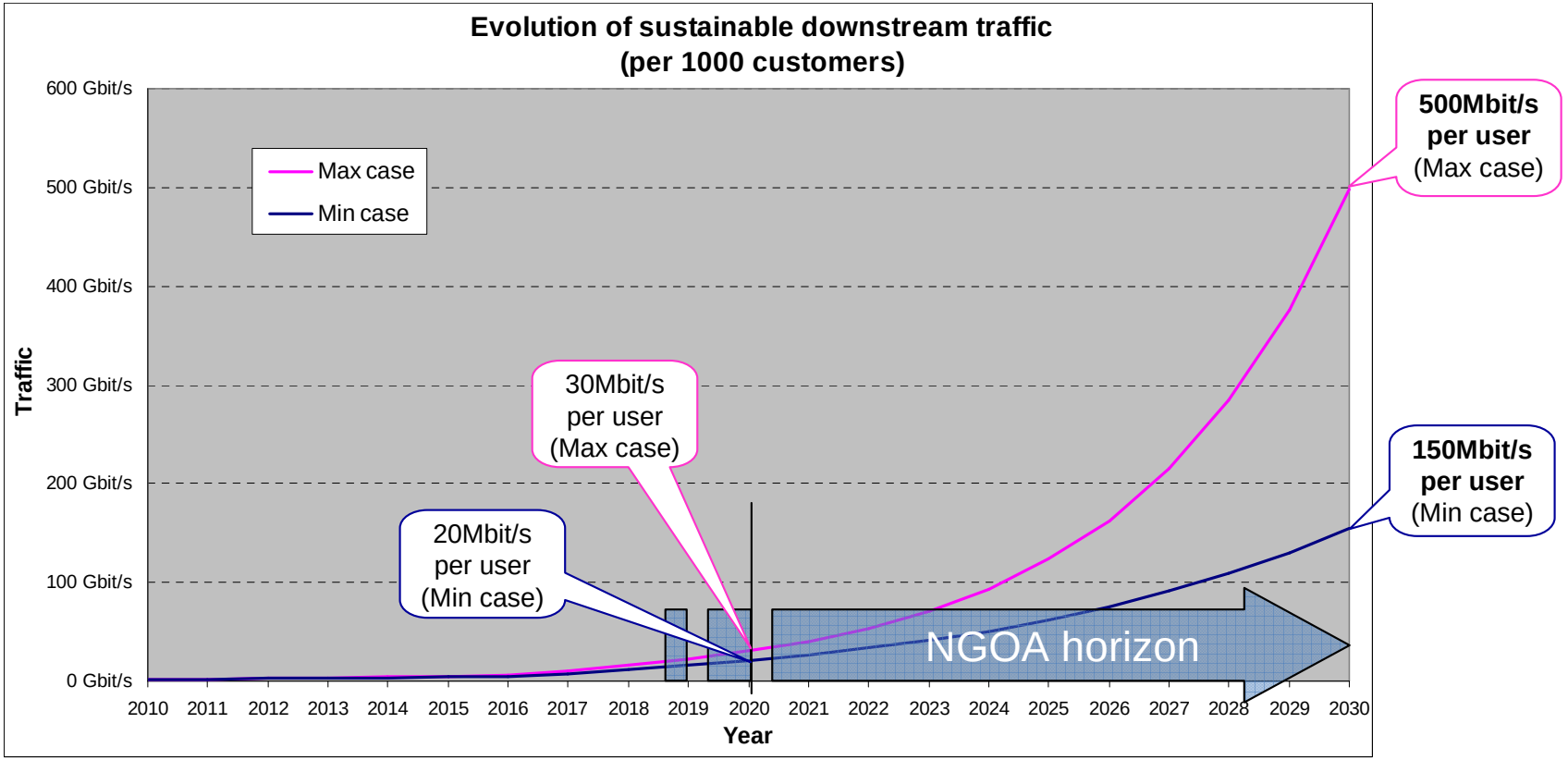
Traffic dimensioning



Network traffic dimensioning of access and feeder segment

- Access peak data rate targeting at least 1 Gbit/s
- Average sustainable (guaranteed) data rate targeting 500 Mbit/s per user, based on service usage during peak hour

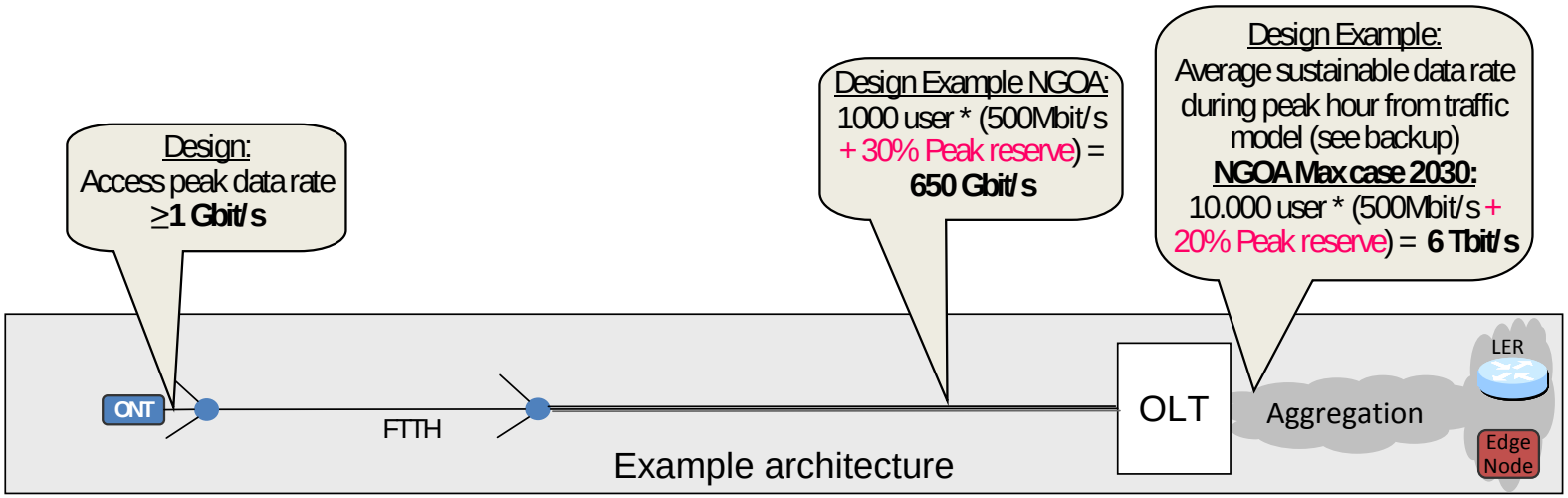
Traffic dimensioning



Forecast of sustainable traffic per user

Traffic dimensioning

Dimensioning example for the predicted traffic demand in 2030



Traffic dimensioning conclusion

Sustainable Bandwidth based on Traffic forecast model:

•Average sustainable downstream based on service usage during peak hour 500 Mbit/s per Optical Network Units (ONU -s)/customers

•Support of traffic symmetry, at least a ratio of 1:2 between upstream and downstream

•Support of 128 Gbit/s up to 500 Gbit/s aggregate capacity per feeder fibre

Network Operation requirements

General requirements on operation

•Support functions and systems for operations, administrations and maintenance (OAM)

•Process automation to minimize manual switching's and increase process efficiency

•Next generation Naming and Numbering addressing schemas

•Standardized Systems

•High availability

•Low power consumption

Provisioning

•Technology neutral e-t-e provisioning of All-IP service portfolio (zero touch after initial roll-out)

•Do it your self installation capable NT -s

•Customer NT should be not customer specific (means e.g. "colourless")

•Portability of customer identification data, e.g. for location move (nomadic) or provider changes

•Web-based customer self-provisioning and self-configuration

Availability requirements per customer class*

Customer class	e-t-e Service Availability	OF [1/a]	MTBF [a]	MDT [h]	DT [h/a]	Max. failure penetration range
PSTN today	**99,983%**	0,135	7,4	10,9	1,47	**1000**
Residential (driver Voice & IPTV)	99,98%	0,128	7,8	13,6	1,75	**One failure does not affect more than 1000 customers**
Business	99,98%	0,437	2,3	4	1,75	
Wholesale	99,95%	0,547	1,8	8	4,38	
Co-operation	99,98%	0,437	2,3	4	1,75	
Backhaul of mobile stations	99,98%	0,437	2,3	4	1,75	
Backhaul of FTTx	99,98%	0,437	2,3	4	1,75	

*) OF = Outage Frequency;
MTBF=Mean Time between Failures;
DT=Downtime per anno;
MDT=Mean Downtime
OF = DT/MDT
DT = OF*MDT
MTBF = 1/OF – MDT; MTTF > MTBF (MTTF = "mean time to [first] failure")
Availability = 1 – DT/(365*24h

(NGOSS)

Network Operation requirements

Maintenance

•Easy, fast and efficient maintainability and restorability

•Remote manageable of all active network elements

•Seamless SW upgrade without service interruption

•End-to-End service/traffic performance monitoring per customer and service (supervision)

•Remote auto-configuration and management of customer equipment by the operator

Hardware and facilities

•Scalable and upgradable network elements regarding new service req. and demands

•Support of modular hardware and pluggable optical modules (for NT only if economical viable)

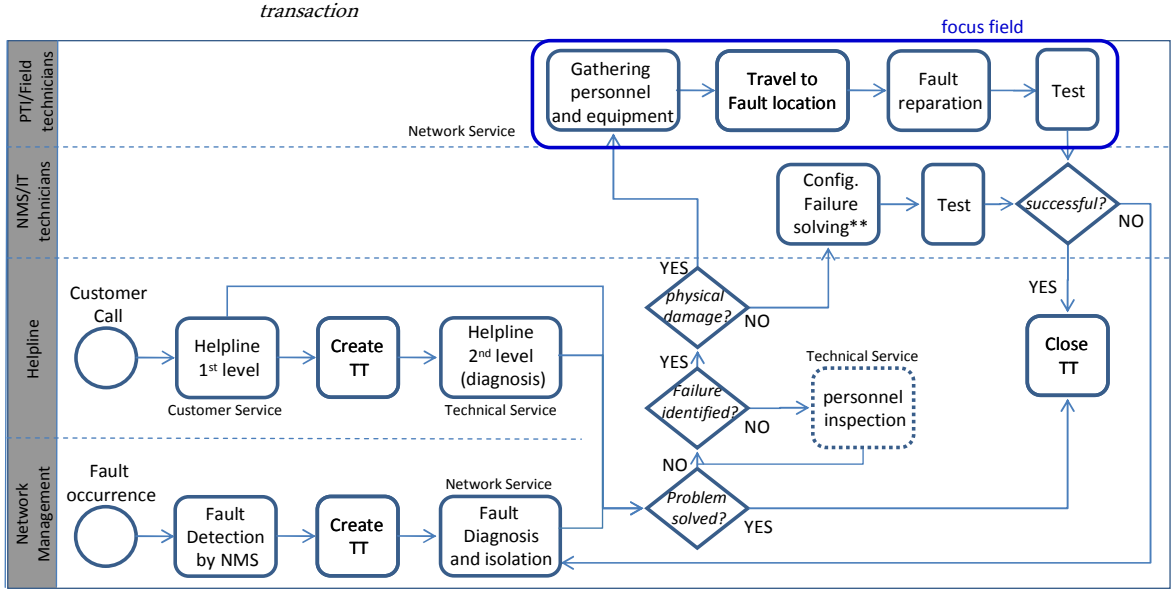
•Small size systems and optical components (esp. OLT, ODF), retaining operation ability

•Reduced power consumption **"Green IT"** and optimized climate concept (e.g. support of a "full power" mode and a "sleep" mode)

•Different customer NT for residential, business and mobile/wire-line backhaul (**Universal NT has to be analyzed**)

•Support of TL9000 Quality Management System

Fault management and Troubleshooting process transaction



Fault management

•Low failure penetration ranges < 1000 User

•Resiliency incl. automatic re-connections through redundant network concepts

•IT supported optical diagnosis and measurement solutions up to the home for fault prevention ,detection and localization

Co-operation requirements

Drivers for co-operation (operators perspective):

- Cost and efficient production
- Shorter time to market
- Sharing of investment risks
- Enhanced market power
- Competitors alternative technologies

Requirements

- Support of co-operation network interconnection and open access enabling interoperability across different carrier networks
- Functions to be supported and provided via a "Co-operation" interface: Connectivity & Forwarding, QoS, Multicast, Security, AAA & Auto-configuration, CPE control, Management & OAM

Regulation requirements

Current situation:

•Regulation is focused on the actors and their market position

•EU directives and guidelines (Access Directive (2002/19/EC), Universal Service Directive (2002/22/EC), Guidelines on Significant Market Power (2002/C165/03), etc.).

•Competition law – punishing businesses for anti-competitive behaviour (*ex post* regulation).

•Sector specific regulation – where it is judged that a company has significant market power (SMP), the market can be regulated in advance of any anti-competitive behaviour (*ex ante* approach).

•Diversity of market situations and practice in EU countries

Applicable Remedies for NRA(National Regulatory Authorities):

•price control, including cost orientation – limiting wholesale pricing to the cost of maintaining the access network

•transparency – the basis of wholesale pricing must be made public

•accounting separation

•non-discrimination – wholesale prices not dependent on purchase volume

•mandatory access to specific facilities – typically access to the central office

•mandatory provision of specific facilities – e.g. power in the central office

Summary of key requirements

Network:

- Support from **256 to 1024** ONUs/customers **per feeder** fibre
- Support of **128 Gbit/s to 500 Gbit/s aggregate** capacity **per feeder** fibre
- Support of **20 to 40 km passive reach** option for the working path, depending on the degree of node consolidation
- Support of **60 to 90 km extended reach** option for the protection path, depending on the degree of node consolidation
- Extended reach should be realized **passively** (preferred solution)
- **Legacy** ODN **compatibility** desirable
- **Flexible and agnostic** interfaces (optical and service layers)
- **Security** better than XG-PON1

Summary of key requirements

Service:

- **Full service access** with high quality, accessibility, retain-ability and security
- The applicable markets of **mobile and fixed backhaul, residential, and business**
- FTTH **residential** peak data rates **≥1 Gbit/s**
- **Business**, backhaul (fixed, mobile) peak date rate: **≥10 Gbit/s**
- **RAN transport**: Low delay, synchronization
- Average sustainable **downstream** based on peak-hour service usage of **500 Mbit/s** per Optical Network Unit (ONU)/customer
- Support of more **traffic symmetry**, with ratio of at least 1:2 between upstream and downstream
- QoS support with at least **four QoS classes**

Summary of key requirements

Operations and Business:

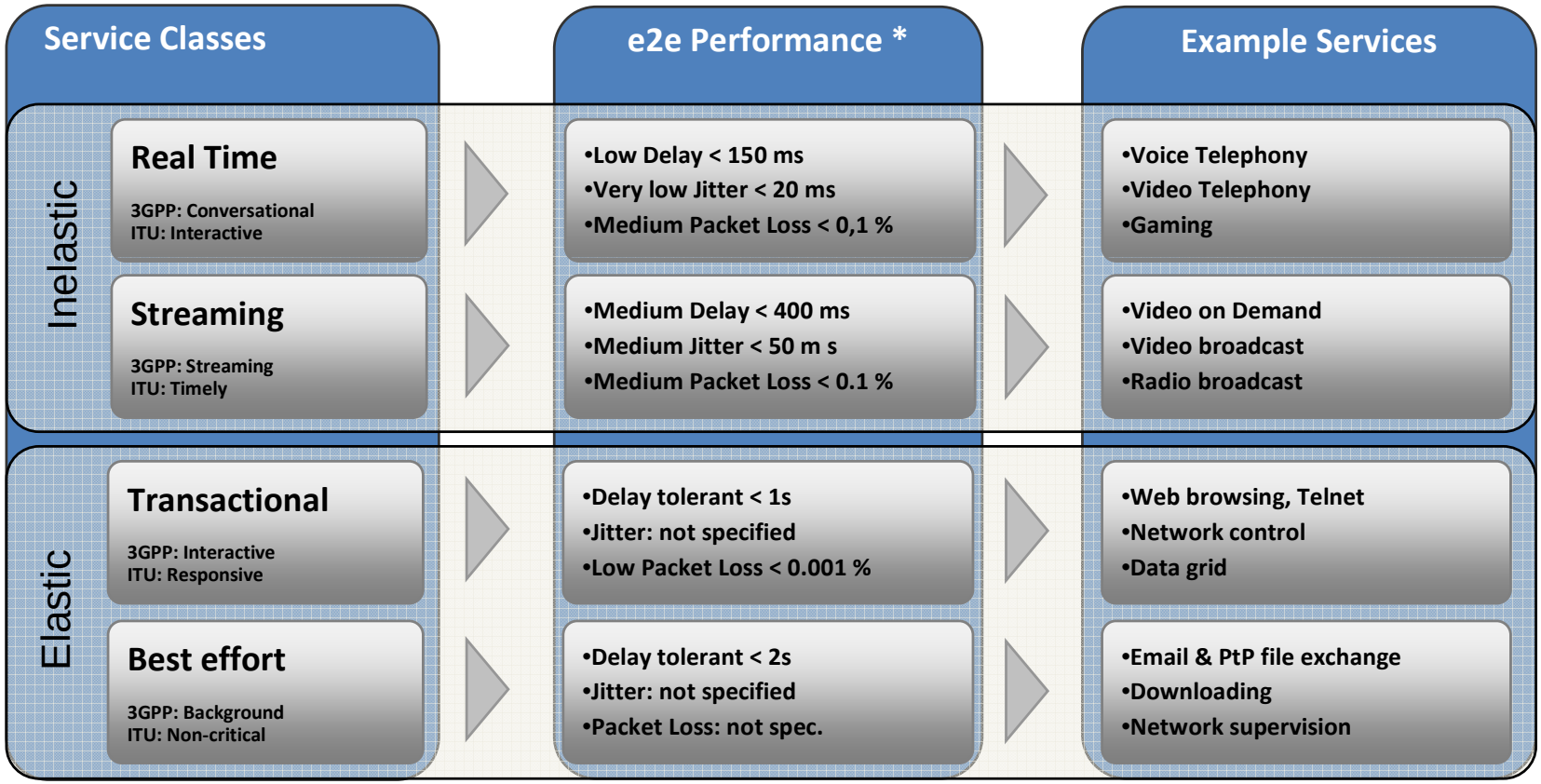
- Support of **co-operations**, e.g. open access (e.g. L1, L2, L3)
- **Low power** consumption
- **High availability** options
- Support of **auto-configuration, remote-management and network monitoring** to automate operation processes: provisioning, maintenance and fault management
- Simplification of operational processes by suitable network design e.g. **DIY** (Do It Yourself) installable ONUs, non-wavelength-specific ONUs
- **Regulatory specifications** have to be fulfilled



Thank you for your attention!

Back-up

Service Classes as defined by MUSE and 3GPP



* Performance values not specified by MUSE

End to End Service quality parameters from MUSE*

Residential End user services	Blocking probability	Availability	Application set-up time	Connection set-up time	Delay	Jitter	BER	Packet loss rate
Voice	<5%	99,98%	<2s	<300ms	<150ms	<20ms	1,00E-05	1,00E-03
Video conference/ telephony	<1%	99,98%	<2s	<300ms	<150ms	<10ms	1,00E-05	1,00E-03
HSI Web browsing; data grid	<0,1%	99,95%	<1s	<3s	<1s / page	N/A	1,00E-07	1,00E-05
HSI Email; Data up-/download	<0,1%	99,95%	<1s	<3s	N/A	N/A	N/A	N/A
HSI Gaming	<0,1%	99,95%	<1s	<3s	<50ms	<1ms	1,00E-07	1,00E-05
Cloud computing	<0,01%	99,95%	<500ms	<3s	<200ms	N/A	1,00E-07	1,00E-05
Live-VoD (streaming)	<0,01%	99,95%	<500ms	<3s	<400ms	<50ms	1,00E-05	1,00E-03
IP TV channel (content)	<0,01%	99,98%	<500ms	<3s	<400ms	N/A	1,00E-05	1,00E-03
IP TV unicast (zapping)	<0,01%	99,98%	<500ms	N/A	<200ms	N/A	1,00E-05	1,00E-03
Business End user services								
Business E-Line (ptp)	<0,01%	99,5% Standard 99,99% Premium	<500ms	<300ms	<150ms	<20ms	1,00E-07	1,00E-05
Business E-LAN and E-Tree	<0,01%	99,7% Standard 99,9% Premium	<500ms	<300ms	<150ms	<20ms	1,00E-07	1,00E-05

* National network (Note: International and intercontinental e-t-e services have usually higher requirements, especially voice and video conference)

Evolution of average downstream bandwidth per service class [Mbit/s]

	Today	Min case*		Max case*		Traffic symmetry ratio**	Traffic relation types
End user services	**2010**	**2020**	**2030**	**2020**	**2030**		
Voice	0,15	0,15	0,15	0,15	0,15	100%	peer-to-peer unicast or anycast
Video conference/ telephony	0,5 – 2,0	4	10	7	30		
HSI Surfing, gaming, data	0,25 – 2,0	4	60	12	500	25%	unicast e.g. surfing, anycast e.g. gaming
HSI VoD (up-/download)	1,0 – 3,0	20	200	40	900	35%	
VoD dedicated (not HSI)	2,0 – 6,0	25	150	50	750	0%	unicast
Cloud computing	2,0 – 2,5	18	150	38	700	50%	unicast
Live-VoD (streaming)	4,0 – 10	10	160	10	160	0%	unicast
IP TV channel (content)	4,0 – 10	10	160	10	160	0%	multicast
IP TV unicast (zapping)	5,0 – 13	13	208	13	208	0%	unicast
Business services	per e-t-e service (not per end-user line)						
Business E-Line (ptp)	25	40	66	100	410	100%	peer-to-peer unicast
Business E-LAN (mptmp) and E-Tree (ptmp)	50	80	133	200	820	80%	peer-to-peer unicast, multicast or anycast
Mobile Backhaul services	per mobile cell						
Access peak data rate	1,000	1,000	5,000	2,000	10,000	50%	all types possible
Average data rate	100	300	1,000	600	4,500		
Fixed Backhaul services	per FTTx node (Assumptions: 50 – 200 users per field node → ∅100 users)						
Access peak data rate	1,000	3,000	6,000	4,000	10,000 (bottleneck)	10%	all types possible
Average data rate	200	1,500	3,000	2,000	5,000		

* Based on the traffic model described in the appendix.

** The traffic symmetry ratio considers only the payload traffic (no control traffic)

*Evolution of TV format bandwidths**

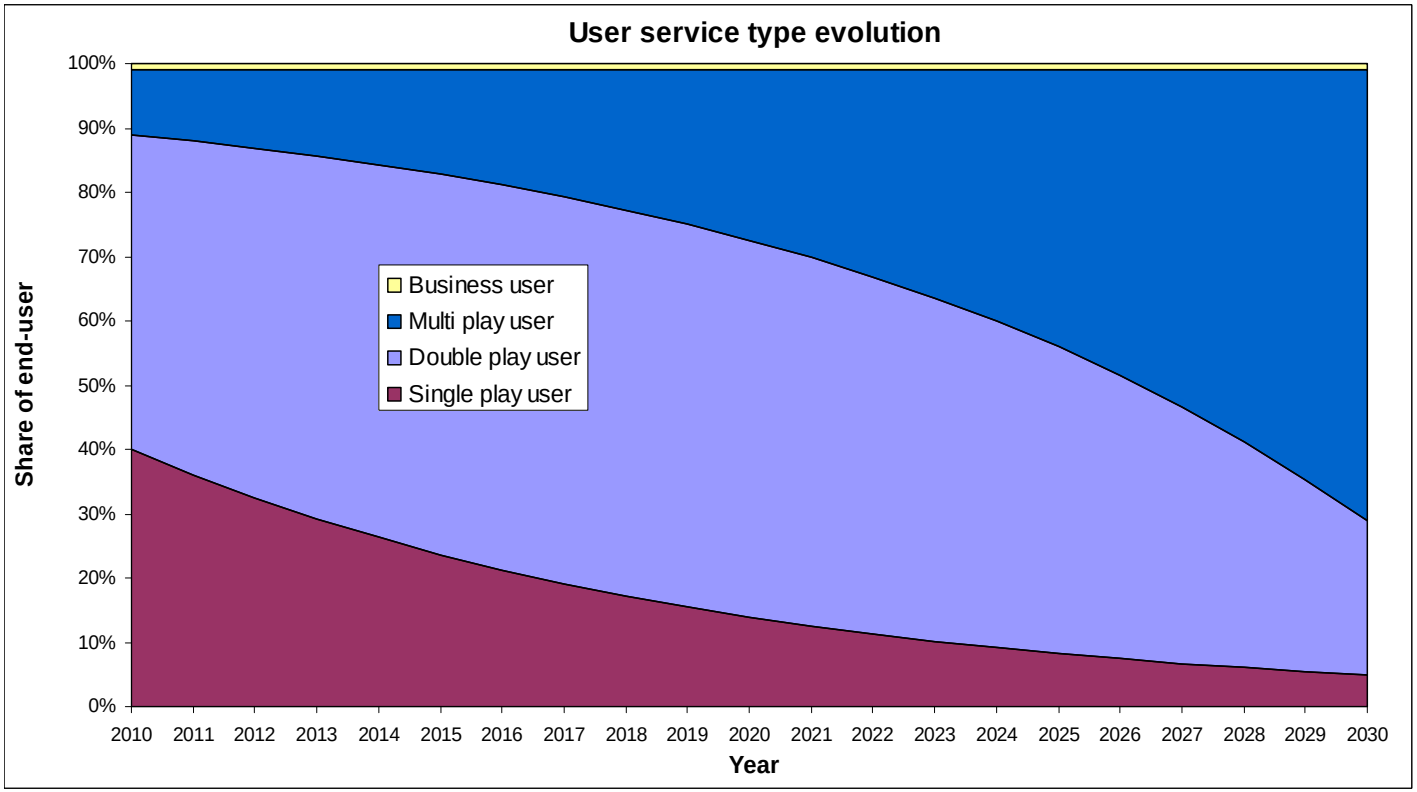
TV service	Busy hours in the different countries of Europe	Average bandwidth per channel per TV format	Traffic relation types
SDTV-Channel	6pm – 1 am	4 Mbit/s	multicast
HDTV-Channel		10 Mbit/s	
4kTV-Channel		80 Mbit/s	
8kTV-Channel		160 Mbit/s	
Live VoD-SD		4 Mbit/s	unicast
Live VoD-HD		10 Mbit/s	
Live VoD-4k		80 Mbit/s	
Live VoD-8k		160 Mbit/s	
Zapping-SDTV		5 Mbit/s	unicast
Zapping-HDTV		13 Mbit/s	
Zapping-4kTV		104 Mbit/s	
Zapping-8kTV		208 Mbit/s	

* The diversification of busy hours across Europe shows a wide range of time-frames according to the local habits of different countries.

Possible NGOA access areas in Germany with different consolidation degrees (γ).

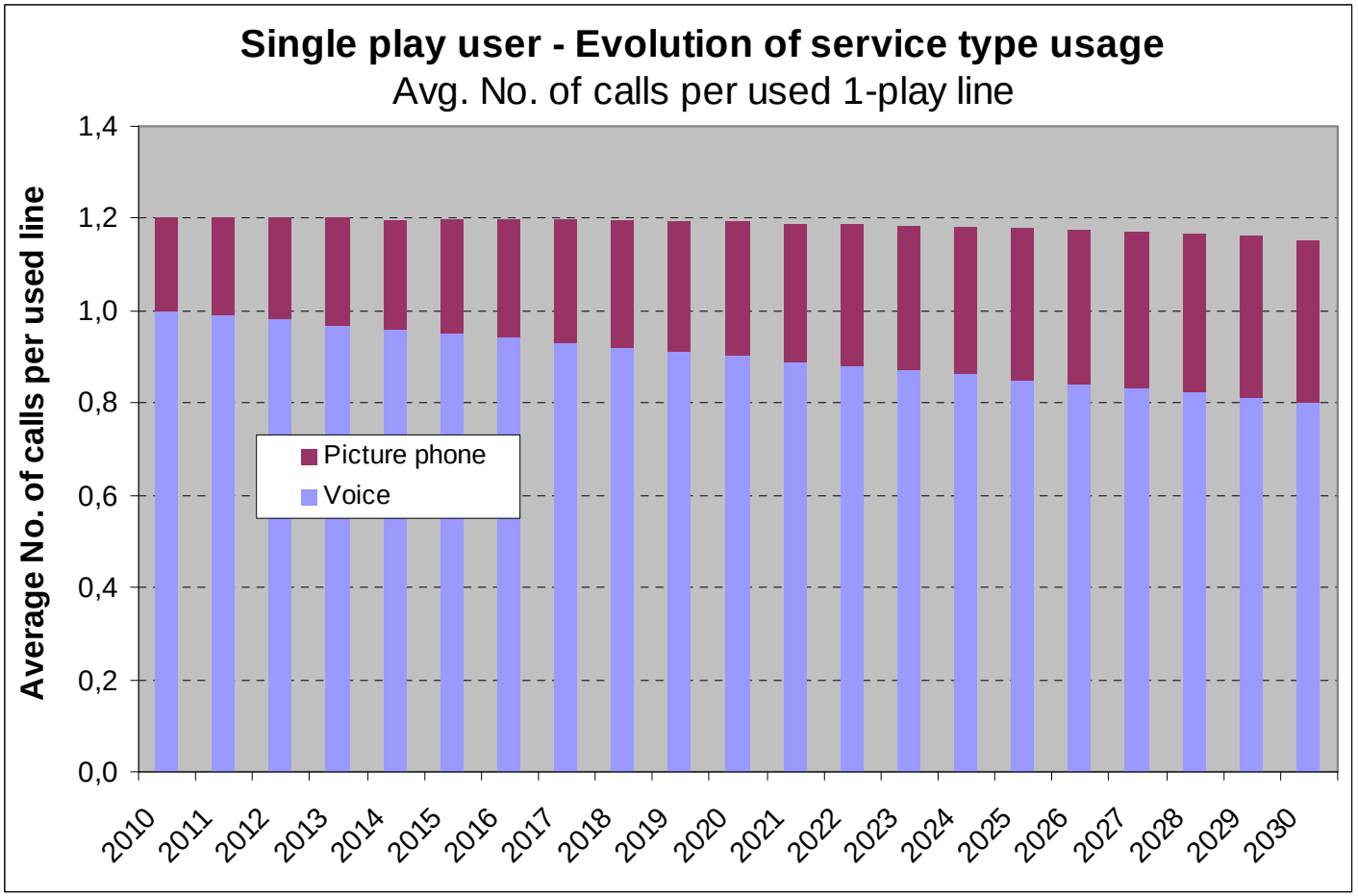
		γ=98.75%			γ=93.75%			γ=87.5%			γ=7	
		NGOA Service Area category			NGOA Service Area category			NGOA Service Area category			NGOA Service	
		dense urban	*urban*	*rural*	*dense urban*	*urban*	*rural*	*dense urban*	*urban*	*rural*	*dense urban*	*urb*
Parameters describing the NGOA service area categories												
mean **area** covered by NGOA service area		150km²	2300km²	4350km²	40km²	390km²	850km²	15km²	155km²	485 km²	10km²	7
mean **number of traditional service areas** per NGOA service area		21	64	82	7	16	15	3	6,5	8,5	2,5	
mean **percentage of dense urban traditional service areas** per NGOA service area		68%	11%	1%	81%	11%	0%	83%	8%	0%	83%	
mean **percentage of urban traditional service areas** per NGOA service area		32%	41%	15%	19%	55%	12%	16%	60%	11%	17%	
mean **percentage of rural traditional service areas** per NGOA service area		0%	48%	84%	0%	34%	88%	1%	32%	89%	0%	
mean **number of households** per NGOA service area		320.000	610.000	265.000	115.000	130.000	60.000	41.000	50.500	33.000	33.500	25
mean **number of household per local traditional service area**		13.500	19.000	9.000	18.500	14.500	9.500	15.500	13.000	8.500	19.000	1
mean **number of households per remote traditional service area**		15.500	9.500	3.000	16.000	7.700	3.600	14.000	7.000	3.200	10.000	
mean **number of low bandwidth business customers** per NGOA service area		2.600	14.500	5.600	5.500	4.400	730	2.700	1.600	360	2.200	
mean **number of high bandwidth business customers** per NGOA service area		10	65	20	30	20	2	13	7	1	10	
ODN / first mile distance in traditional service areas *(80% quantile related to number of households)*		1,5km	2,5km	3,5km	1,5km	2,5km	3,5km	1,5km	2,5km	3,5km	1,5km	2
mean feeder link length	working path	6km	23km	40km	4km	11km	18km	2km	7km	12km	1km	
*(average value related to **100%** households)*	backup path	11km	38km	72km	7km	21km	45km	5km	16km	32km	3,5km	
mean feeder link length	working path	5km	19km	35km	3km	8,5km	16km	1,5km	5,5km	11km	1km	2
*(average value related to **90%** households)*	backup path	10km	33km	65km	5,5km	16km	39km	4,5km	13km	30km	3km	8
mean feeder link length	working path	4,5km	16km	31km	2,5km	7km	13km	1km	4km	9km	0,5km	
*(average value related to **80%** households)*	backup path	10km	28km	59km	5km	13km	32km	4km	11km	27km	2,5km	6
mean feeder link length	working path	3km	9km	19km	1km	3,5km	7km	0,5km	2km	5km	0km	0
*(average value related to **50%** households)*	backup path	8km	16km	39km	3,5km	8km	21km	1,5km	5,5km	20km	0,5km	2
Percentage of households in NGOA service area with	working&backup path	34%	55%	82%	14%	45%	65%	1%	27%	55%	0%	
cumulated feeder and first mile distance >10km	backup path	70%	80%	90%	35%	65%	75%	20%	55%	65%	14%	
Percentage of households in NGOA service area with	working & backup path	0%	40%	70%	0,5%	14%	35%	0,5%	7%	22%	0%	
cumulated feeder and first mile distance >20km	backup path	8%	55%	75%	10%	30%	55%	3%	25%	47%	2%	
Percentage of households in NGOA service area with	working & backup path	0%	20%	48%	0%	1%	8%	0%	0,1%	1%	0%	
cumulated feeder and first mile distance >40km	backup path	0%	30%	65%	0,5%	10%	35%	0,5%	7%	25%	0,0%	
Percentage of households in NGOA service area with	working & backup path	0%	11%	36%	0%	0%	2%	0%	0,0%	0,1%	0%	
cumulated feeder and first mile distance >60km	backup path	0%	23%	51%	0,5%	4%	21%	0,0%	2%	13%	0,0%	

Service usage evolution



- Single play ratio falls from 40% to 5% till 2030
- Double play ratio rises from 50% up to 60% till 2017 and falls to 25% till 2030
- Multi play ratio evolves from today 10% to 70% in 2030 (saturation after 2030)

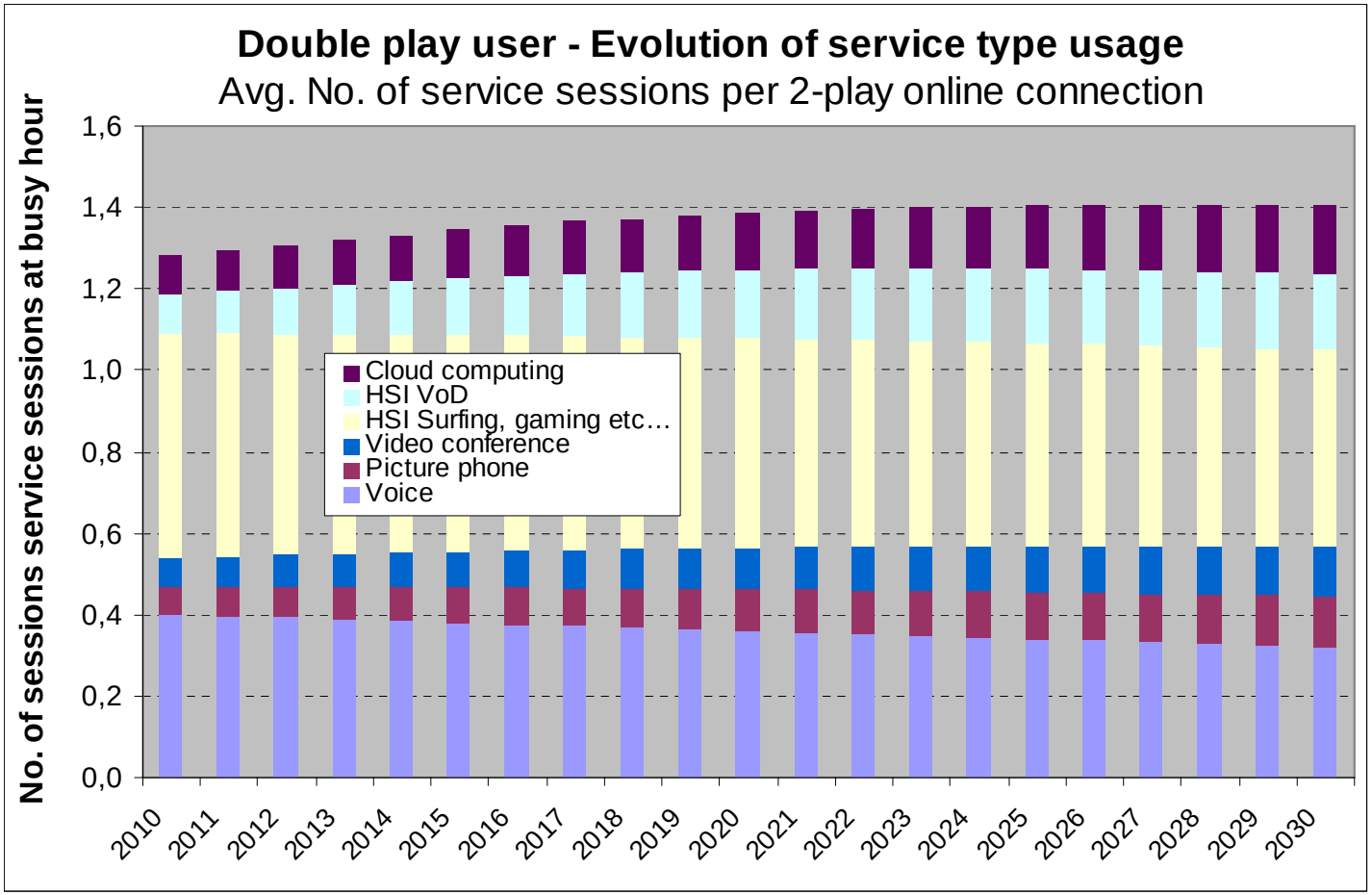
Service usage evolution



Session usage assumptions – Single play user

- ∅1,2 calls per used line at busy hour
- >10% concurrency at busy hour
- Ratio of picture phone rises over time

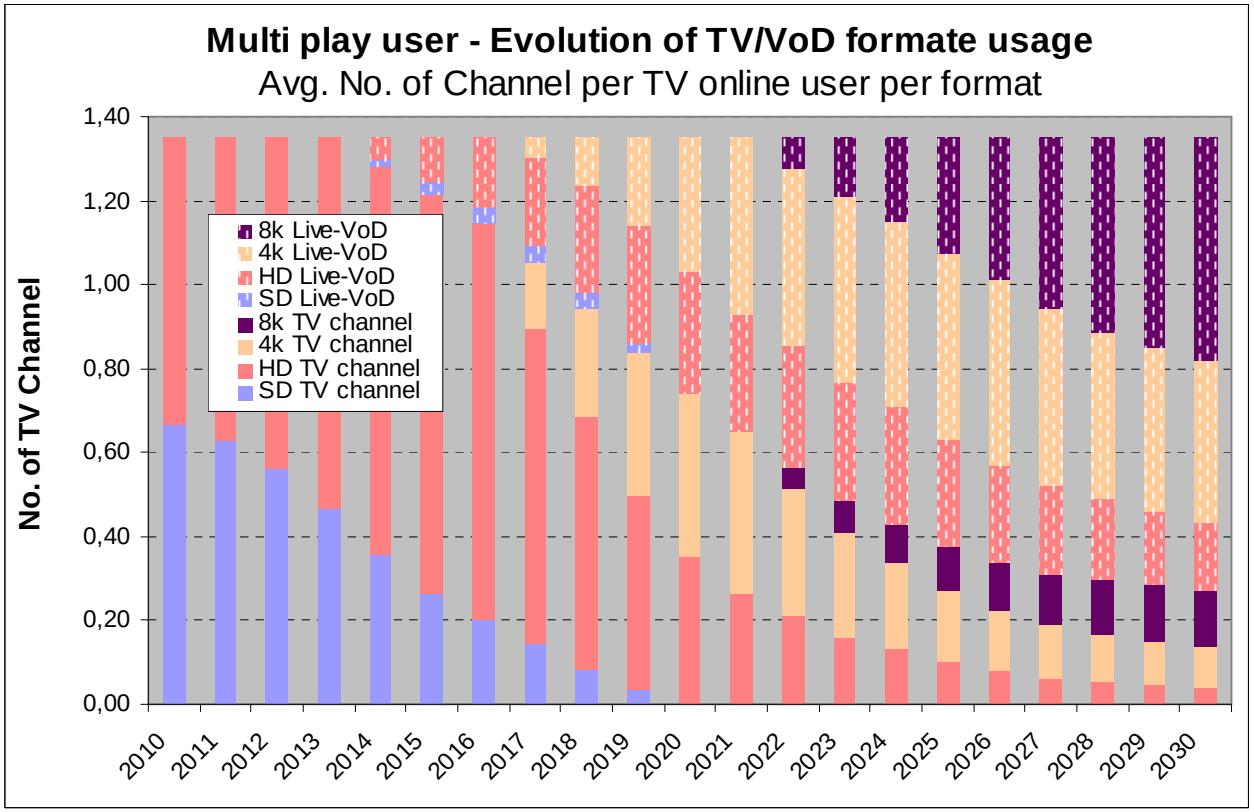
Service usage evolution



Session usage assumptions – Double play user

- ∅1,35 service sessions per online user at busy hour
- >40% concurrency at busy hour
- Ratios of cloud computing, HSI-VoD, Video conference and picture phone rise over time

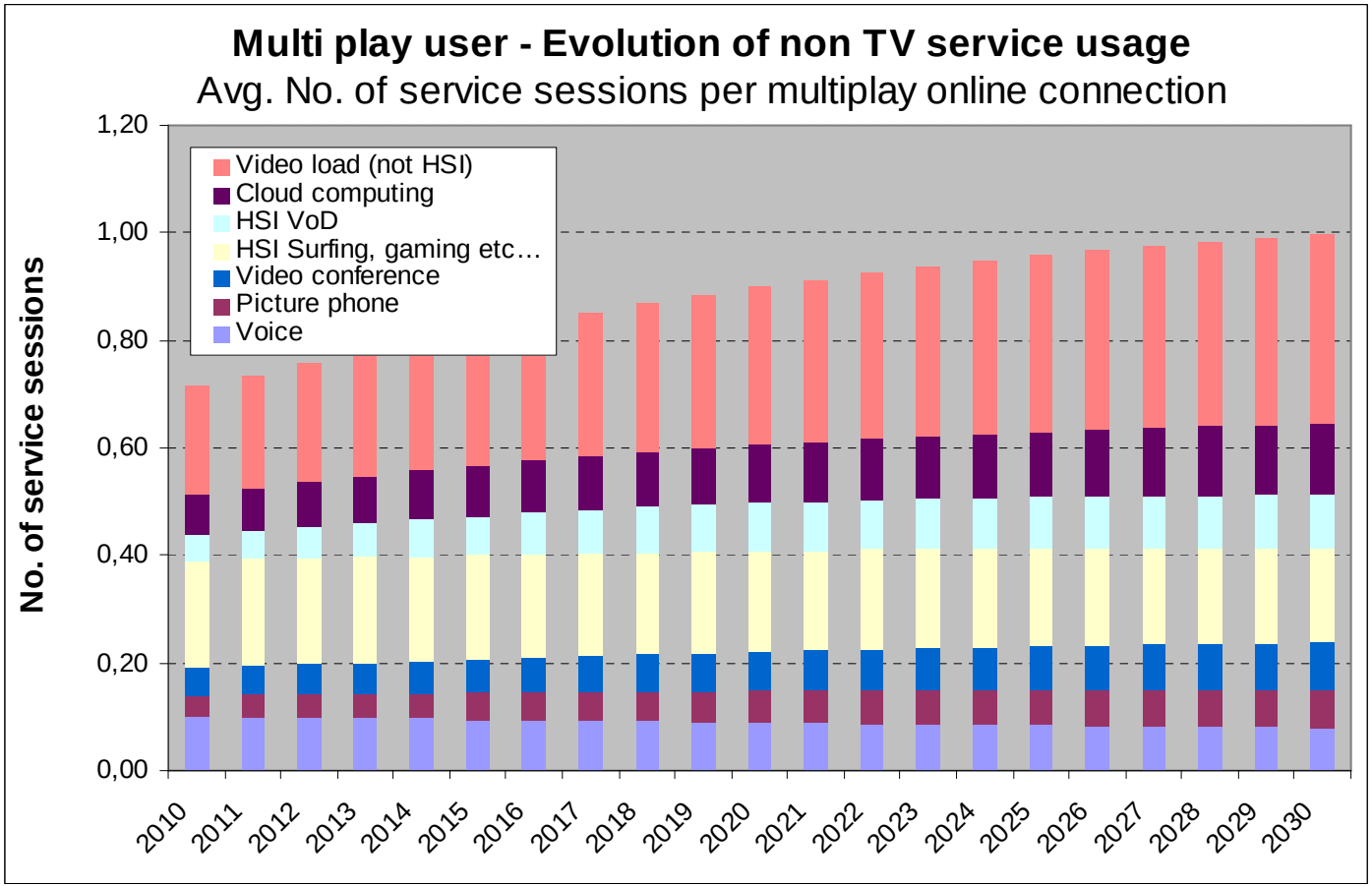
Service usage evolution



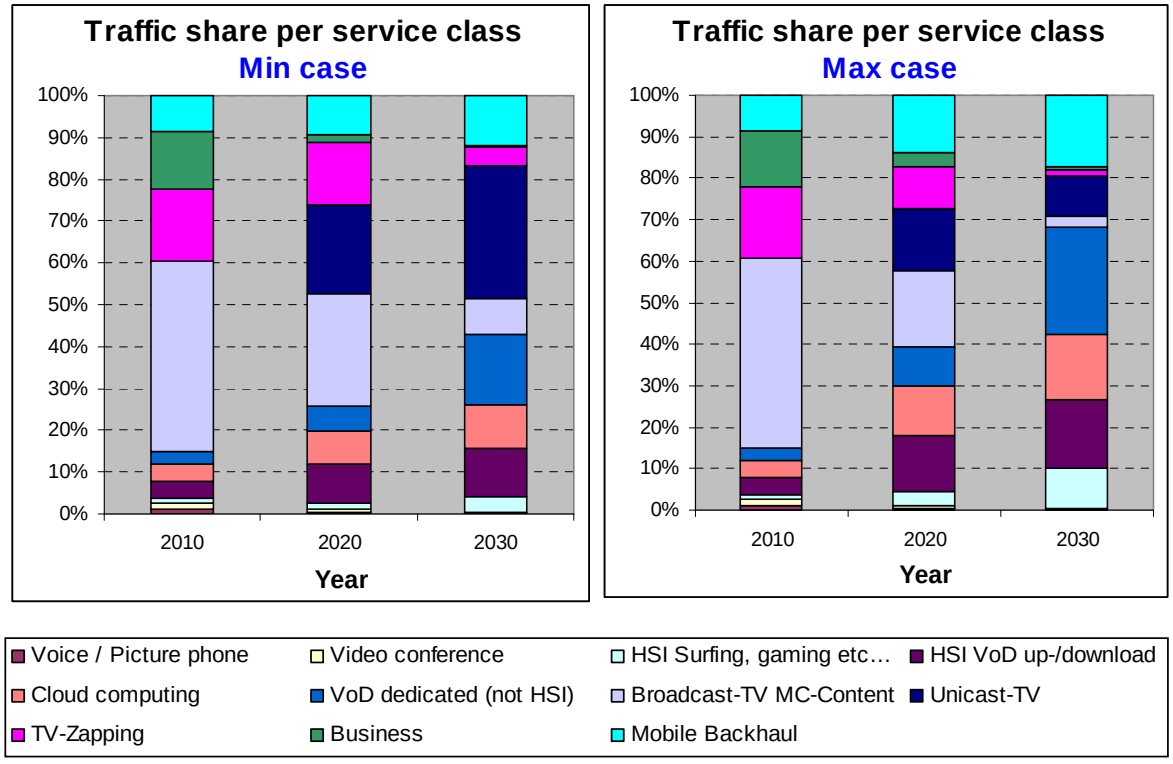
Session usage assumptions – Multi play user

- IPTV usage
  - *60% concurrency at busy hour*
  - *∅1,35 channels per TV user (or per STB e.g. Picture in Picture) ◊ fix over time*
- Evolution from SDTV towards UHDTV
  - *Example 2020: SDTV 0%, HDTV 40%, 4kTV 60% (start in 2017), 8kTV (0%)*
  - *Channel bandwidths: 4 Mb SDTV; 10 Mb HDTV; 80 Mb 4kTV; 160 Mb 8kTV*
- IPTV unicast zapping
  - *Zapping time < 1 sec (not noticeable)*
  - *1,3x channel bandwidth (all formats)*
  - *>30% simultaneous zapping requests at busy hour*
- Evolution towards Live-VoD
  - *Evolution from TV multicast services towards VoD unicast services (Live-VoD share in 2030 > 75%)*
- 3D-TV
  - *Ratio rises over time up to 80% in 2030*
  - *1,5x channel bandwidth (all formats)*
- Cloud computing
  - *20% of multi play customers use non TV services at busy hour (Voice, HSI ...)*

Service usage evolution

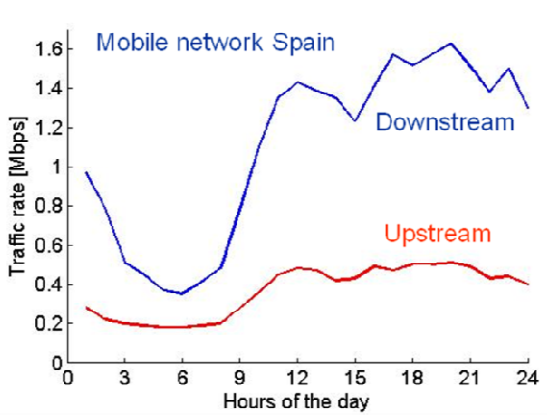


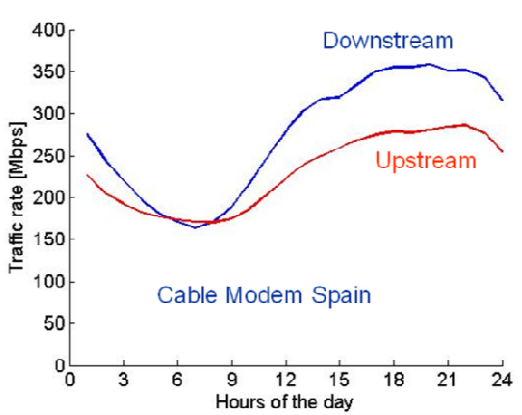
Service usage evolution

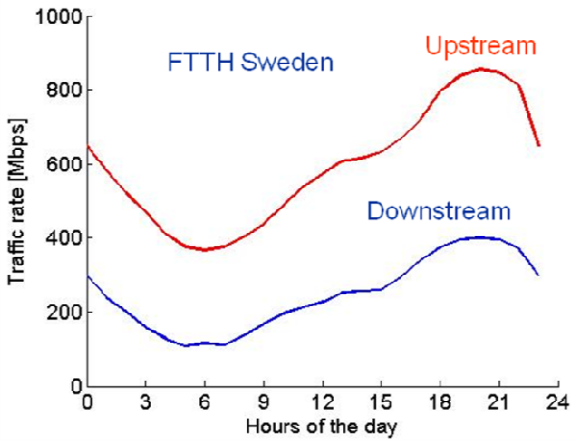


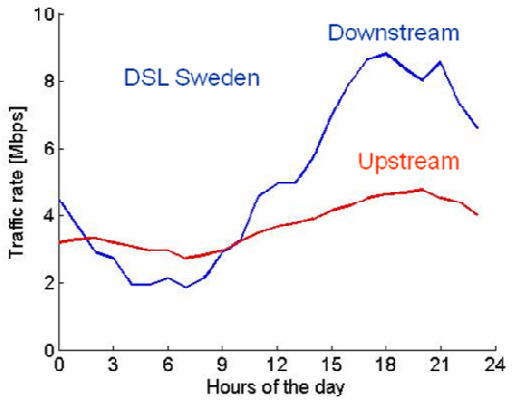
Traffic share per service class at busy hour

Traffic Symmetry (Eureka TRAMMS)



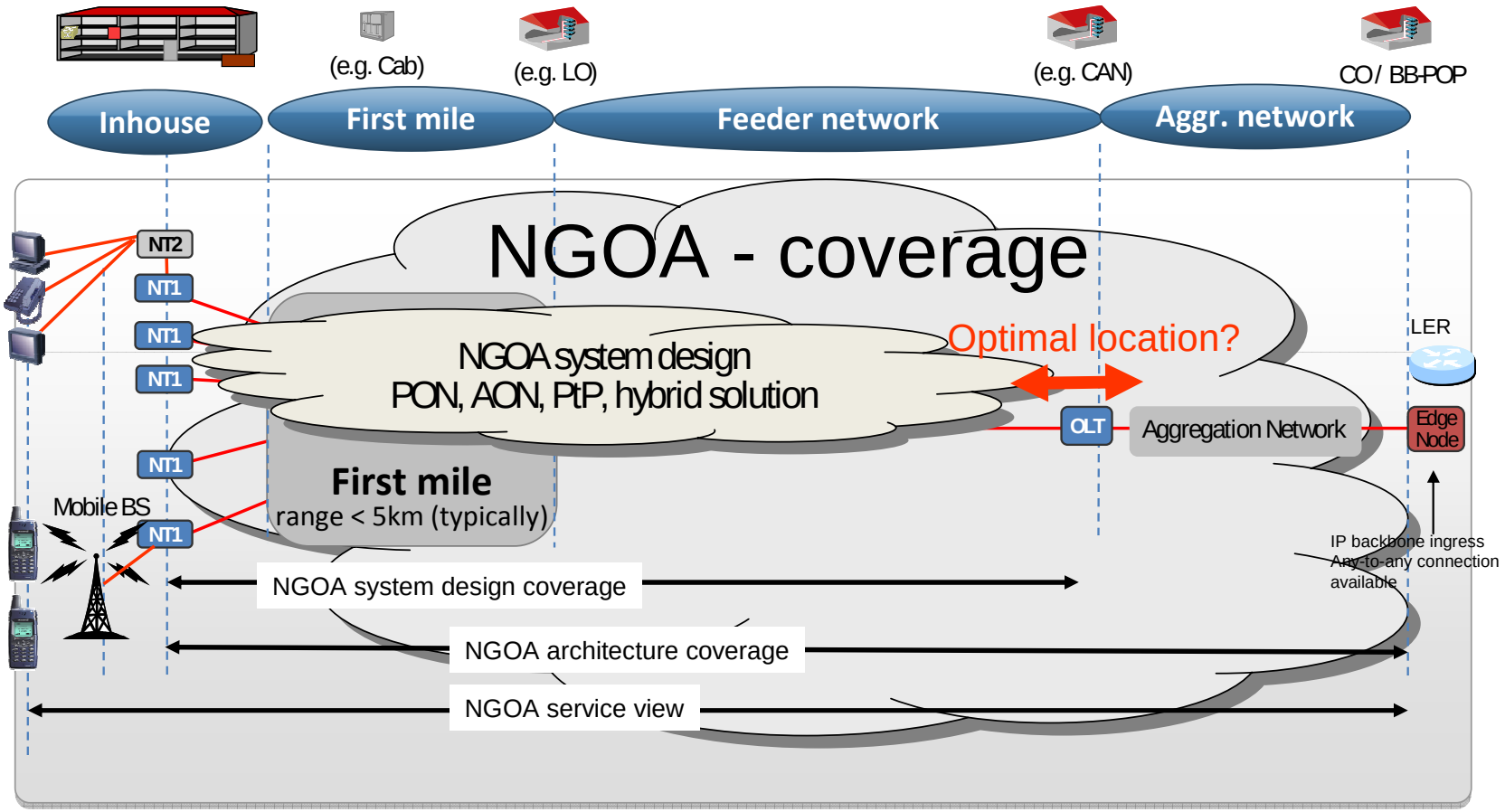






Traffic measurements in four different networks in Sweden and Spain

NGOA coverage in different views for OASE



* LO = Local Office (also known as LEx)
CAN = Consolidated Access-Node (also named consolidated LO)
CO = Central Office
BB-POP = Broadband Point of Presents (IP backbone ingress point)

Different OSI Layer to be covered from OASE project in an NGOA